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ABSTRACT

This is a teacher's guide for a module designed to integrate environmental education into ninth- and tenth-grade chemistry classes. The module, pilot tested in Gwinnett County, Georgia in classes of students, many of whom had learning disabilities, emphasizes activity learning and considerable review. The module is divided into four parts. Part one is on water sources, part two on water quality, part three on sewage treatment, and part four (the water game) is a review. There is a total of 14 activities designed for 14 days. Summary statements, broad objectives, discussion topics and questions, supplementary resources, and helpful hints are given for each activity. Also included in the guide are a list of overall objectives, the module sequence, and a list of equipment and supplies. (BB)

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Science

Teacher's Guide

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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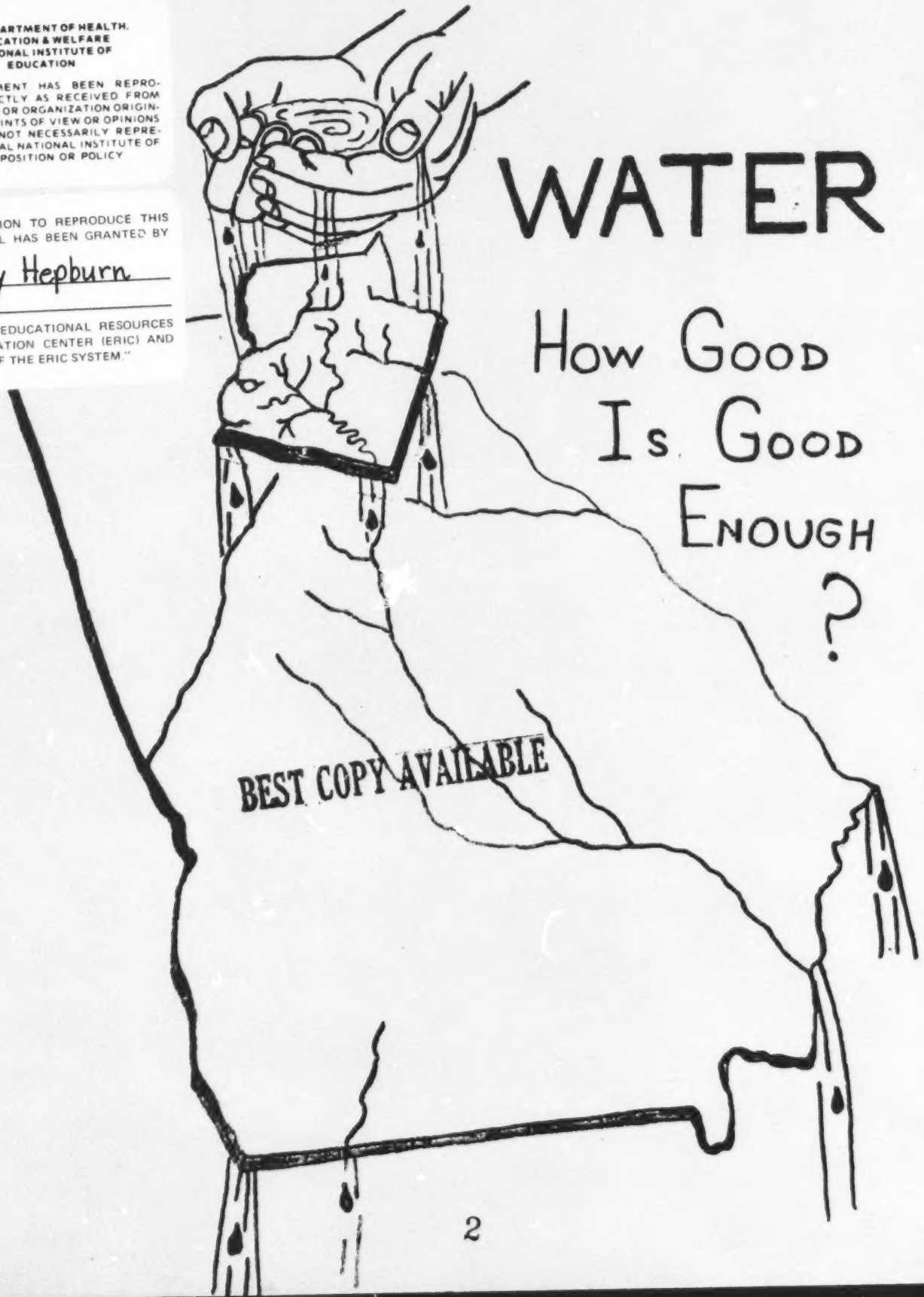

WATER

How Good Is Good Enough?

BEST COPY AVAILABLE

SE 024 445

TEACHER'S GUIDE

FOR

WATER: HOW GOOD IS GOOD ENOUGH?

Science Module

(9th-10th grade Chemistry)

Pilot Tested in Gwinnett County, Georgia, 1975-1976

Developed by ENVIRONMENTAL EDUCATION FOR THE SECONDARY SCHOOLS, a curriculum project of the College of Education of the University of Georgia, Dr. Mary A. Hepburn, Director. This project (Project No. 522AH51215) was supported by the U.S. Office of Education under the Environmental Education Act. All rights reserved.

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Environmental Education for the Secondary Schools is a curriculum project which developed these instructional materials to help high school students respond intelligently to environmental policy issues. Utilizing local issues to stimulate interdisciplinary thinking and environmental problem solving, the modular materials are coordinated for social studies and natural science classes.

Project Team

Environmental Education for the Secondary Schools, 1975-1976

University of Georgia Staff:

Mary A. Hepburn, Director and Social Studies Coordinator
John W. Shrum Science Coordinator
Marsha Scheppler, Social STudies Research Assistant
James E. Nix, Jr., Science Education Research Assistant
Carol Taylor, Science Education Research Assistant

Gwinnett County School District Coordinators and Teachers:

Richard M. Johnson, Director of Secondary Insturction
Betty Bentley, Vice-Principal, Berkmar High School
Kyle Vermillion, Materials Reviewer and Science Teacher
Dianne Vennett, Social Studies Teacher
Lynn Gatlin Social Studies Teacher
Ruth Lewis, Science Department Head
Ruth Stockel, Social Studies Department Head

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(Copy Masters are included for ditto, xerox or other type of copying.)

MODULES SEQUENCE

1. OPENING
   Immersion in Environmental Problems by Means of

   -- Dramatic Episode (Factual or Fictional Based on Fact)
   -- Perplexing Situation - News Reporting Style
   -- Visual series or a Visuals/Quotations Montage

2. INFORMATIONAL STAGE
   Build Foundations for Decision-Making by providing

   -- Data and Perspectives for building to summary statements or generalizations
   -- Summary statements for analysis and application to other sets of data
   -- Values "Situations"

3. UTILIZATION - OPPORTUNITY TO APPLY PREVIOUS LEARNING TO A PARTICULAR PROBLEM STUDIED IN MORE DEPTH

   -- Case Study or Detailed Report
   -- Comparative Study
   -- Multiple Perspectives

4. ACTION - EXPLORATION OF CHANNELS FOR INDIVIDUAL AND GROUP ACTION

   -- Individual Action
   -- Obtaining Information, Familiarity with Agencies of Research, Information and Service
   -- Interest Groups or Pressure Groups
   -- Publicity - Keeping Others Informed
   -- Civic Action - Using formal Political Channels to provide a public forum on the issue to bring about change and improvement

5. EVALUATION

   -- Evaluate learning outcomes
   -- Internal evaluation of modular instructional unit
   -- Estimate apparent community effects

Environmental Education for The Secondary Schools

Overall Objectives

Cognitive

Students will be able to:

-- define conditions of their environment in terms of interrelationships of the biotic and abiotic components

-- gather, organize and relate environmental data from science and social studies

-- relate first hand field investigation and experimentation to more abstract environmental knowledge

-- specifically delineate sources of population problems, water problems, land use problems and waste disposal problems in the county community

-- focus on public issues in selecting areas for scientific - environmental experimentation

-- utilize science knowledge in making social decisions

-- identify, examine and evaluate consequences of alternative public responses to given environmental problems and the potential trade-offs involved

-- determine channels for citizen action on specific issues and compare them

-- relate detailed knowledge of local environmental problems to environmental problems of the state and region

Affective

Students will:

-- demonstrate involvement in local environmental issues

-- demonstrate a commitment to using the knowledge and skills of science and social studies in analyzing environmental problems and determining action

-- express interest in other related problems of the state and national environment

-- demonstrate a rational, evaluative attitude toward making environmental choices

Introduction

The EESS chemistry module and a parallel social studies module on water quality and supply were developed by EESS for classes of A-level students many of whom have reading disabilities. Activity learning and considerable review are emphasized in the material.

This guide provides supplementary material and teaching suggestions to assist you in teaching this science module and in communicating the environmental concepts related to water supply and quality.

The module is divided into four parts with a total of fourteen activities. Summary statements, broad objectives, discussion topics and questions, supplementary resources, and helpful hints are given for each activity. Please check the material list far enough in advance to order films or supplies.

The instructional sequence presented here is designed for 14 days. Supplementary activities, including suggested media for analysis or review, may increase the time of instruction by several days.

Teacher Preparation

EESS CHEMISTRY MODULE

Equipment and Supplies Needed

Activity		Equipment	Supplies
Part I	1		Field Trip Questions
	2		Topo Map -- Gwinnett County
	3	Overhead Projector	Transparencies
	4	Air pump 5 gallon, small mouth bottle Stopper with rubber hose attached Overhead Projector	matches Transparencies
	5	1 aquarium/group 1 stream table/group 1 overflow bucket/group 1 1 liter beaker/group 1 coffee can with holes/group	1 lg. bucket sand/group water
Part II	6	6 beakers (500-100 ml)/group 6 watch glasses/group	vinegar salt detergent or fertilizer clay or fine soil alcohol (isopropyl) water
	7	5 petri dishes with nutrient agar/group (Allow sufficient time to prepare agar dishes) dropper & bottle (Cl_2 solution) Overhead projector	1 liter raw stream water or sewage effluent from school 50-60 ml chlorine solution (1 ppm)
	8	7 beakers (liter)/group 6 pipets or grad. cylinders/group 7 stirring rods/group	turbid water (suspended soil, sewage) aluminum sulfate solution (1 gm/liter)
	9	3 beakers (liter)/group 1 grad. cylinder/group 3 stirring rods/group	pH indicator test paper aluminum sulfate solution 1 M HCl in dropping bottle 1 M NaOH in dropping bottle Turbid water (as in #8)

Activity		Equipment	Supplies
	10	16 mm projector	Film - The Gifts
Part III	11	Overhead Projector	Transparencies
	12	per group: 1 plastic spoon 2 beakers (400-600 ml) 2 small grad. cylinders or syringes 1 stirring rod 4 test tubes (at least 10 ml) 1 test tube holder 1 marking pencil Overhead projector	distilled water powdered milk dry yeast methylene blue in dropper bottle (lactic acid - optional)
	13		graph paper or regular tablet paper
Part IV	14	Game	

* * * *

Requests for audio visual materials from the Environmental Protection Agency should be sent to:

Mr. Robert L. Towner
Training Section, U.S. E.P.A.
Region IV - Environmental Research Laboratory
College Station Road
Athens, Georgia 30601

Or phone (404) 546-3161

* * * *

Some Gwinnett schools may have available the Environmental Education Kit which contains additional materials that may be used in water studies - particularly a filmstrip and a tape.

Activities Sequence and Teaching Suggestions

Part I - Water Sources: Where Do We Get Our Water

Part I deals with problems of water supply. Although the focus is on Gwinnett County the concerns are typical of most communities.

A good summary or review exercise for Part I is the use of the comic book information bulletin, The Story of Water Supply by "Willing Water." This color bulletin can be obtained in small numbers from the Gwinnett County Water Department. Copies can be obtained in bulk by writing the American Water Works Association, 6666 West Quincy Avenue, Denver Colorado, 80235. This booklet could be effectively used after Activity 4.

Additional materials from the water department of the county government or Atlanta Regional Commission in Atlanta may be of interest.

Important Vocabulary

potable	hydrologic cycle
sedimentation	precipitation
filtration	percolation
aeration	evaporation
chlorination	condensation
topographic map	condensation nuclei
contour line	water table
Eastern Continental Divide	surface runoff

Activity I

Objective:

Observe and generally describe the major source of Gwinnett County's water supply and the treatment process this water goes through before it reaches the consumer.

Notes:

The teacher is advised to make a preliminary tour of the water treatment facilities before the students to become familiar with the facilities and the processes used there. The trip would aid in leading discussion and answering questions. Contact Mr. Ackerman in the Gwinnett County Water Department to arrange for the field trip (also remember to schedule a school system bus in advance.)

At the time of the writing of this module the new water treatment facility near Buford had not been opened. Classes using this module after June of 1977 should consider a field trip to the new facility.

The questions from pages 2 and 3 of the text are provided on the next page so a ditto master or transparency can be made.

1. Where does the water at the plant come from?
2. Why does the water have to be treated?
3. In the treatment what materials are removed?
4. Is anything added during the treatment?
5. What records of the water treatment must be kept?
6. What does "potable" mean?
7. What tests are made to determine if the water is potable?
8. How does the water get from the treatment plant to consumers?
9. How much of the water from the plant goes to homes?
   To businesses and industry?
10. How much of the county's water supply comes from this plant?

To answer these questions use notes which you take on the trip and organize it with additional information which you obtain in class.

Activity 2

Objectives:

1. Explain the relationship between the Eastern Continental Divide and the Gwinnett County water system.
2. Predict or make a judgment on the effects on Gwinnett County of someone upriver dumping wastes into the Chattahoochee River.
3. Describe the locations or places that could potentially be affected by Gwinnett County dumping wastes in the rivers flowing from the county. Predict some of these effects.

Notes:

Lead students to discover the Eastern Continental divide which runs through Gwinnett County. On a topographic map or a map clearly showing the rivers, students can trace the direction of flow of rivers and generally determine the ridge as it runs across Georgia. (A transparency can be made from the map in this manual.)

After students have talked about this divide, have them read in Activity 2 the section concerning this. Point out that streams and rivers flowing in either direction from the County are affected by what Gwinnett Countians do to the water.

Also trace the flow of the Chattahoochee River noting the route it flows before reaching the county and the potential sources of pollution before and after it reaches Gwinnett

Color indexes to the map symbols on page 6 are available from: The United States Geological Survey Distribution Section, 1200 S. Eads Street, Arlington, Virginia, 22202. Also contact the Georgia State Geological Office in Atlanta (404- 656-3214) for detailed surface maps of the Atlanta metro area.

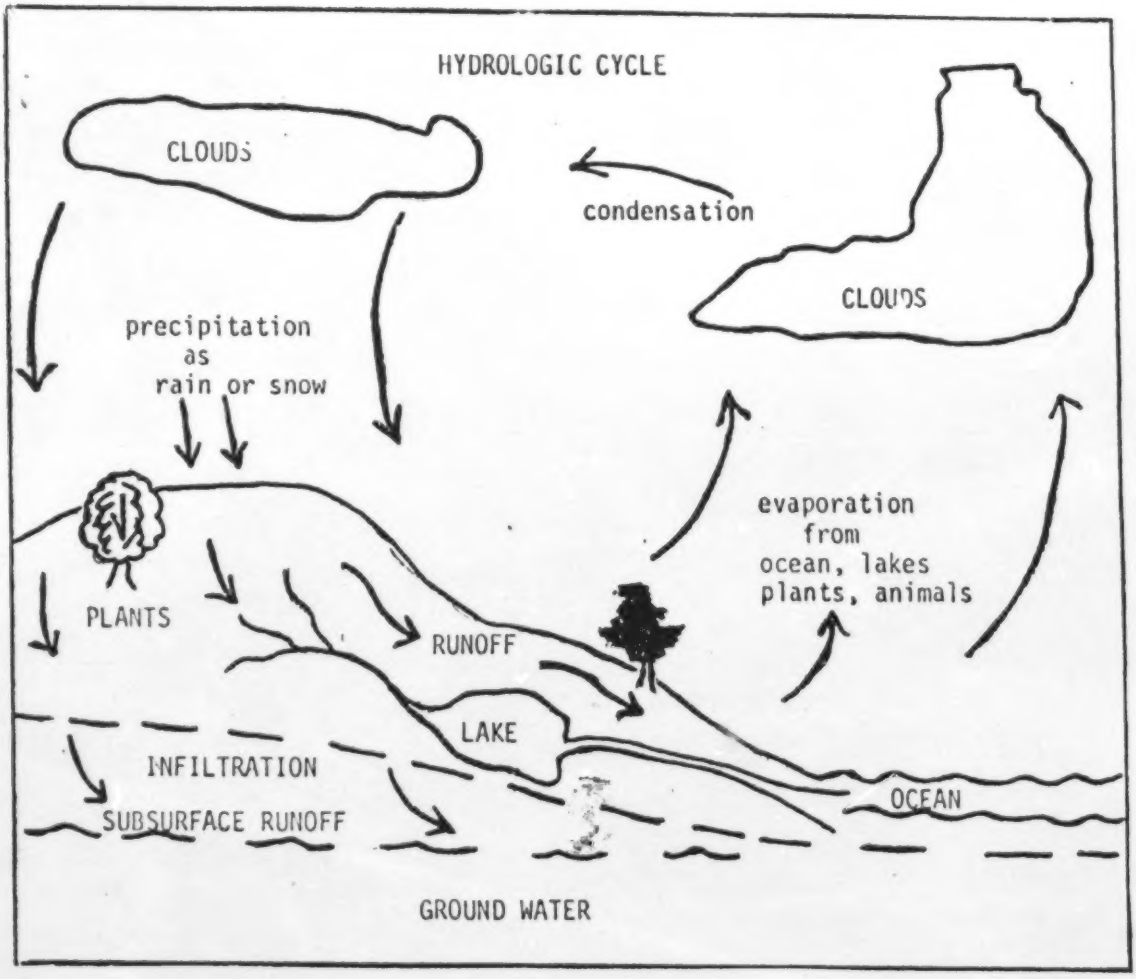
Activity 3 - The Hydrologic Cycle

Objectives:

1. Describe the hydrologic cycle and its significance in providing fresh water.
2. Compare the amount of fresh water available to man to the total amount of water present on earth.

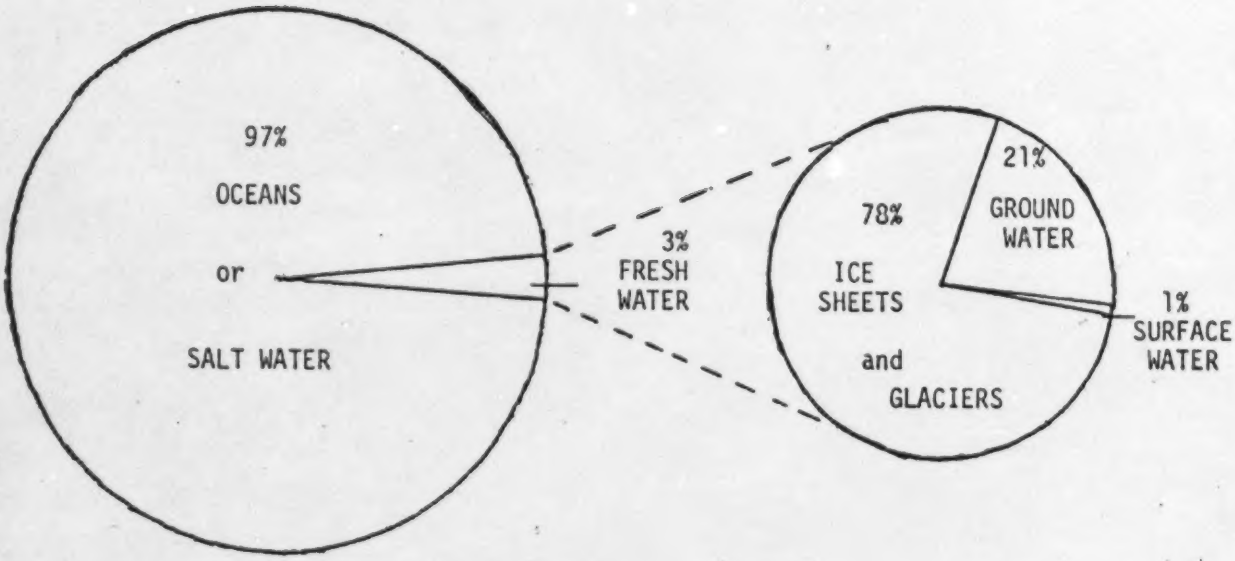
Notes:

The hydrologic cycle is an important concept. The charts and overhead transparencies should help the students grasp the importance of this cycling of water. Use the chart in the teachers manual to make a transparency. Some additional questions to spur thought are: 1) Can you trace the ways water is used and recycled, to be used again? 2) In what ways does nature function as a kind of water treatment plant? Compare the actions of this cycle to Gwinnett County's water treatment facilities. 3) How has the



100% precipitation as rain, hail, sleet or snow
- 70% evapotranspiration
- 22% returned to the oceans in streams and groundwater
- 8% withdrawn and used
  - 3.4% irrigation
  - 3.4% industry
  - .6% municipal

DISTRIBUTION of the EARTH'S WATERS



Drainage Map of Georgia

water in the ocean become salt water? 4) If the ocean is salty, how does it contribute to our supply of fresh water?

Point out how little of the world's total supply of water is fresh water, how much of this fresh water is held within glaciers and ice sheets; and finally the small amount of surface fresh water. The chart in the student book shows these percentages. An overhead transparency may also be helpful here.

Activity 4 - Cloud Formation Demonstration

Objective:

Explain the effects of pressure and condensation nuclei on cloud formation.

Notes:

One might mention that "rain-making" is carried out by airplanes that fly through clouds spreading silver iodide crystals. The crystals serve as condensation nuclei and hopefully cause rain to fall. If time permits one might also mention some of the ecological and political factors involved in attempts to alter weather. Also a good topic for discussion would be the potential effects of air pollution on cloud formation and rainfall.

This exercise may be completed in less than one period. If so, you might want to either go on to Activity 5, use review exercise The Story of Water Supply, or show one of the films listed in Activity 5.

(Copy Master)

The Story of Water Supply

Study Questions

1. How much water does the average American home use each day? How does this compare with the total used by each person?

2. By using a "pie diagram," show how the water is used in a typical community.

3. Make an outline of the various significant historical events that have led up to the modern water works. (Material found on pp. 4-5.)

4. How did the ancient Indians and Egyptians purify their drinking water?

5. Which early civilization used settling reservoirs to help clean their water supply?

6. Describe the event in Hamburg, Germany, that indicated that water filtration is very valuable.

7. When and where was the first mechanical filter plant built in the U. S.?

8. What is the importance of the Hydrologic Cycle? Draw a diagram of the process.

9. What are three major sources of water used by municipalities?

10. Why does ground water usually require less treatment than does surface water?

11. Draw a diagram of a typical water treatment plant, label main areas and show the flow through the plant.

12. List four industries that use a great quantity of water to produce their products. Also, indicate the quantities used.

13. If you have a leak at home that loses 50 cubic feet of water each day, how many gallons will you lose each day? Each year?

14. Explain why the authors stated that, "a city without an adequate water supply is a city without a future."

(questions by Kyle Vermillion)

Activity 5 - The Water Table and Surface

Objective:

Describe some of the activities that would potentially affect the quality and quantity of underground and surface water supplies. Analyze a given situation in which the natural contour of the land is disrupted and predict some of the effects on a nearby water supply system.

Notes:

This activity is designed to aid the student in learning what the water table is like; some of the factors affecting the water table; some of the effects of surface runoff; and the ways in which surface runoff can be altered. The students should read the questions in the student book before attempting the activity. The questions are designed to hopefully lead the student beyond the relatively simple observations involved. Some students may require assistance in this area. Note the films "Stormwater Pollution Control," dealing with urban runoff (30 min.) and "Man's Responsible for the Earth," dealing with the careful use of pesticides (13 min.) are available from the EPA. The address is given with the material listing. The two films can be used as supplementary material if the module needs to be lengthened or if they would draw attention to local problems. NOTE: APPOINT STUDENTS TO MONITOR WATER COLLECTION BUCKETS TO PREVENT OVERFLOW.

Part II Water Quality: How Do We Make It Safe To Drink?

Part II deals with experimental procedures that relate to processes used at the water treatment plant and with an overall look at the problem of water quality. The teacher should attempt to parallel each activity with concepts discussed earlier. The last activity, The Gifts, should magnify increasing student concern over the quality of water around them. Encourage students to ask questions about the quality of water in lakes, streams, and wells in the area. Students might bring in water samples to be tested. Allow time for discussion.

Available from the EPA -- 35 mm film strip with cassette narration:

Title	Number	Time
Filtration Plants	F-132a	10 min.
Sampling and Testing Drinking Water	S-140	7 min.

These film strips can serve as review exercises and also to add variety to the instructional presentation.

Important Vocabulary

contaminated	coagulant
sterile	flocculation
control (noun)	pH
turbid	

Activity 6 - Is The Water Safe To Drink?

Objective:

Identify water contaminants that cannot be identified using sight and smell only.

Explain why observation by sight and smell is not sufficient to declare water potable.

Notes:

Six water specimens are needed for each laboratory station. Prepare the six specimens before class as follows:

Specimen (1) potable water - normal school water
Specimen (2) add 10 ml of vinegar per liter of water
Specimen (3) add 10 to 15 gm. of detergent or fertilizer
Specimen (4) add 10 to 15 gm. of table salt per liter of water
Specimen (5) add fine clay or soil to water until the water appears cloudy
Specimen (6) add 15 ml rubbing alcohol per liter of water

Caution the students not to drink or taste any of the samples. The recording sheets should be provided to each student to prevent their using the one in the book. A ditto master can be made from the recording sheet in this manual.

This activity is a lead-in to those that follow in which actual water treatment procedures are applied. This activity is basic to activities 7, 8 and 9 and the limitations of sight and smell should be stressed.

One might encourage students to bring in samples of water from home to test in Activity 7. For those students who become particularly interested in testing water quality, a 35 mm film strip with cassette narration, Sampling and Testing Drinking Water, is available from the EPA.

Appropriate for class discussion at this point is the news article on p. 40 of the textbook. Also of interest here is the article on Lake Lanier pp. 31-32.

Activity 7 - The Water Detective: Effect of Chlorine on Bacterial Growth in Water

Objective:

Describe the effect of chlorine on the growth of bacteria in water.

Explain why chlorination is used in the water treatment process.

Notes:

The preparation of the sterile nutrient agar medium will probably take several hours. Unless a lab assistant is available you should allow sufficient time for this. The water sample should come from a natural source such as a pond or stream. Stress to the students the importance of not tasting the raw water.

The chlorine solution should contain no more than 2 mg of free chlorine per liter of water. Observation time should be allowed on each following class day until results are obtained. You should try to relate this process to the chlorination procedure observed at the water treatment plant. Have the students use mimeograph copies to record observations. A ditto master and a transparency can be made from the page in this manual.

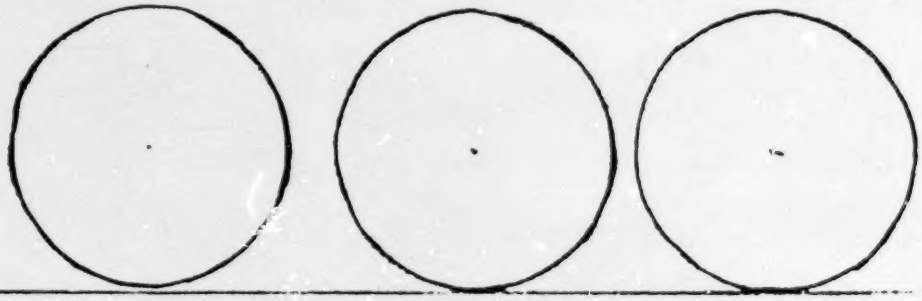
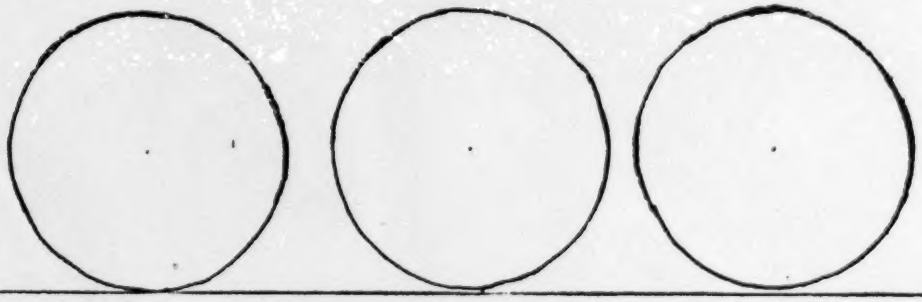
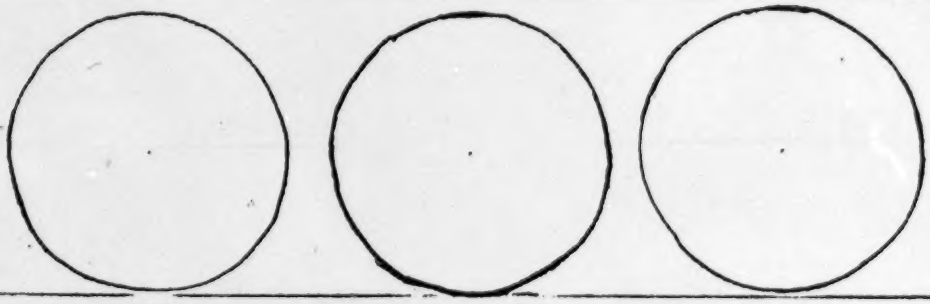
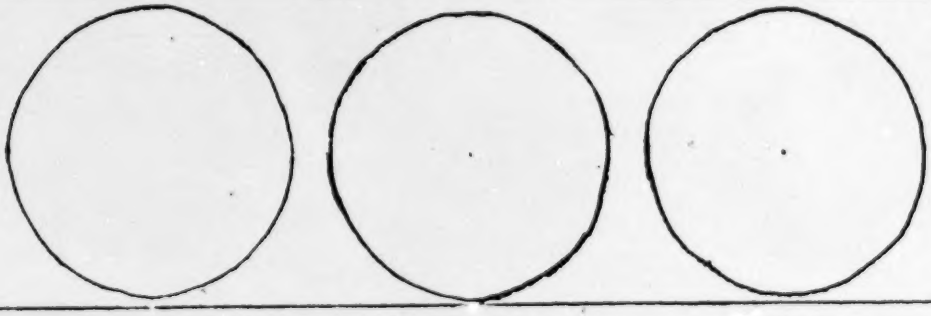
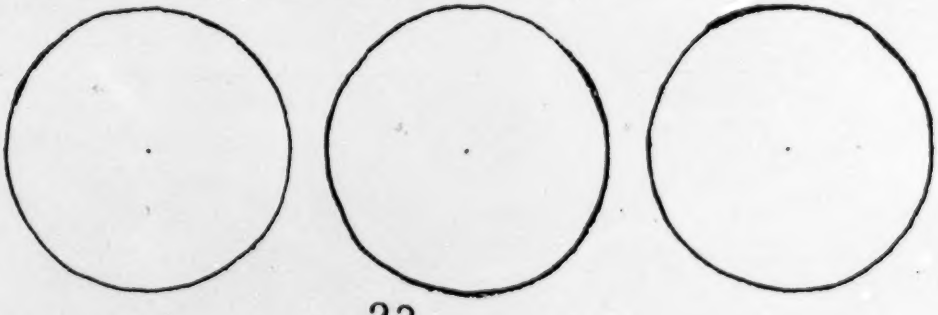
In the time remaining after setting up the chlorine investigation develop some ideas in preparation for coming investigations. e. g. Review the water treatment processes -- mixing and settling filtering, aeration, flouridation. Some students may want to bring in water samples to test for bacterial growth. Don't forget that films and filmstrips on upcoming material are available.

OBSERVATIONS - ACTIVITY 6

Sample No.	COLOR	CLARITY (Turbidity)	SUSPENDED MATTER	SEDIMENT	ODOR	OTHER
1						
2						
3						
4						
5						
6						

(Use for making ditto masters)

Observations of Bacterial Growth

Sample No. and Contents	24 hrs.	hrs.	hrs.
1. Control			
2. Water Only			
3. 1 drop Cl_2 solution			
4. 2 drops of Cl_2 solution			
5. 3 drops of Cl_2 solution			

Activity 8 - Flocculation

Objectives:

(1) Describe the effect of adding a coagulant to turbid water.
(2) Explain why flocculation and settling are used in water treatment processes.

Notes:

Turbid water may be prepared by mixing one cup of soil with enough water to yield about 4 liters. Prepare enough water for each group to have sufficient quantity to work with. The teacher should test the pH of the turbid water or run the experiment before class time. The pH of the samples depends on the type soil used and on local conditions. Variations in the pH are possible and it will help to know what to expect before class time. Do not allow the students to record their observations in the book. If desired, a ditto master can be prepared from the copy in this manual. Point out the relationship between this exercise and the process observed at the water treatment plant.

Activity 9 - pH and Floc Formation

Objectives:

(1) Describe the effect of pH on the flocculation process.
(2) Predict the effects of quantities of acid being dumped into the Chattahoochee River or Lake Lanier above Gwinnett County. Explain why the water treatment plant operators would be concerned about such a situation.

Notes:

This activity is closely related to Activity 8 and is simply an extension of the concepts introduced there. For advanced classes this activity could be altered to be run with Activity 8 or extended to include local water or sewage samples.

Turbid water samples can be prepared as in Activity 8, or the same samples from Activity 8 can be used. Again check the pH of the water sample before running this experiment.

Focus student attention on the discussion questions at the end of the activity. Recall information and ideas from Activity 2 in discussing some of the sources of pollution for the Chattahoochee. Discuss ways in which the pH of water may be affected: runoff from streets and farms, addition of silt, seepage from mines, acid rain caused by SO_2 in the air, industrial wastes, etc. Discuss the effects on Gwinnett County of such pollution.

DATA CHART

Beaker No.	ML. of Aluminum Sulfate Solution	OBSERVATIONS
1	none (Control)	
2	3.3 ML	
3	6.6 ML	
4	10 ML	
5	13.3 ML	
6	16.6 ML	
7	20 ML	

Discuss your observations:

A) What amount of coagulant would you recommend using? Why?

B) Would the use of the water or destination of the sewage after cleansing affect the amount of coagulant you would use?

C) Should you use filtration before or after this procedure? Why?

D) What would be some disadvantages to using a similar technique to clear sewage or drinking water?

E) How does this activity relate to the treatment processes observed on the field trip to the water purification plant?

F) Besides removing suspended matter, what else do you think flocculation might remove?

Activity 10 - The Gifts

The Gifts is a film from the Environmental Protection Agency. This activity should begin to draw together some of the concepts from Parts I and II. In discussing the questions listed in the student module, point out earlier activities related to the ideas in question. For example Question 1 can be related to the material dealing with the hydrologic cycle. Question 2 can be related to activities 5 and 6. Excerpts from the sound track of the film are included in this manual.

The film does discuss several concepts that are not covered by this module. Thermal pollution is not mentioned here. Later sections will deal indirectly with the problem of lake's aging because of the release of excess nitrates and phosphates, but will not specifically cover this aging process. Good resource or background material is given in Fresh Water Pollution by W. T. Edmondson which is included as a chapter in the book Environment edited by W. W. Murdoch, Sinauer Associates, Inc., Stamford, Connecticut, 1971.

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Excerpts From The Sound

Track of The Gifts (25 min. color film)

Building, Breaking and rebuilding. Our cities uncontrolled and unplanned begin to melt one into the other. Released from the age of development into the age of anxiety, people, more than 200 million people. More people, more concrete, more traffic, ... We achieve a kind of greatness, but at what costs. Just as the American dream seemed within reach we found a limit of the American earth. Now every major American city is afflicted with air pollution, every major American river system has poison in it, a third of our fresh water lakes are filthy. So heavy is the air's cargo of dirt that the winds of North America are contaminated. Air and water pollution travel without passport around the globe.

In the beginning we had so much natural wealth it seemed that you could never use it all, we grew careless and wasteful, we embraced every technical advance as progress. We traded on and took advantage of the abundance of nature and failed to see how fragile nature was. We turned our backs on our rivers and lakes, made them sewers and let them decay. . . .

One fourth of the world's supply of fresh water rises in North America, a thousand rivers and 100,000 American lakes . . . . We use more water than any other people, for more bathrooms, more lawn sprinklers, more dishwashers, more water for all the conveniences of affluence. In another generation, we will approach the limits of our usable water supply.

Pollution kills. It kills the water; it kills the life that grows in the water. Much of the worst pollution is hidden, dumped to fester in wooded streams or poured from pipes beneath the water surface. Many of the most deadly water poisons are invisible. Water that looks clean may be only an illusion. . . .

A lake is the memory of summer and youth, but the slow movement of lake water makes it easy to spoil the solution. Thousands of our fresh water lakes are now dying, centuries ahead of their time. Today even the great lakes are threatened. Lake Erie was attacked by the great steel works along it's shores. Lake Erie is loosing the battle. Its once rich commercial fishing industry is gone. Beaches are closed. Lakeshore homes are blighted. Erie's once revitalizing microorganism's are largely giving way to slug worms and the smells of dead water. For the past 50 years Erie has aged 15,000 years.

Now even the oceans are polluted. A million tons of oil are spilt at sea each year. More than 10 million tons are dumped into rivers and bays that run to the sea. Lumps of oil and tar roll in ocean waves throughout the world.

Oil wastes are even entering the organic food chain, we may loose the seas as a part of the food source at a time when the earth's population needs sea protein to survive. . . . Cans, bottles and other wastes litter the deepest floors of the Atlantic Ocean. Oil, detergents, farm poisons, garbage, every form of pollution finally reaches the ocean.

In spite of new federal, state, and local laws to control the pollution, in spite of the billion of dollars spent, in spite of the efforts of business and industry, we have been losing the battle against water pollution; although state and local governments have made a start toward cleaning up. One fourth of our towns and cities have no sewage treatment plants at all. Half the existing plants are outdated and some use methods the Egyptians used more than 2000 years ago.

American industry which astonishes the world with it's genius and power, each day uses more than 160 billion gallons of water -- drawing from streams, rivers and lakes; the water wealth of the country. Much of the water is returned polluted to mingle with refuse from towns, cities and farmlands. . . .

Part III - Sewage Treatment: How Do We Recycle Waste Water?

As the title indicates, this section deals with sewage and waste water treatment. Whenever possible, relate concepts and treatment processes in this part to activities that have already been completed. Gains in cognitive and affective areas should become apparent.

Media

There are several types of instructional media available to teachers which could be used well with Part III of the module.

1. A free film, This River Must Live, is available from the Shell Oil Company Film Library, 430 North Meridian Street, Indianapolis, Indiana, 86204.
2. Several 35 mm Slide and Cassette Tape Presentations are available from EPA (See p. 4 of the guide for address). Some of these are for more advanced study.

	Title	Number	Time
(1)	Upgrading Biological Treatment	XT-25	28 min.
(2)	Dissolved Oxygen Determination	XT-29	15 min.
(3)	Ultimate Disposal to the Environment	XT-30	42 min.
(4)	Margin for Safety	XT-31	18 min.
(5)	Residual Chlorine & Chlorine Demand	XT-37	12 min.
(6)	The Determination of Phosphorous	XT-44	15 min.
(7)	The Determination of Biochemical Oxygen Demand	XT-54	13 min.
(8)	Alkalinity	XT-66	11 min.
(9)	Determination of Alkalinity	XT-69	11 min.
(10)	The Faceless Menace (Air)	XT-101	10 min.

3. Filmstrips and Cassette Tape Presentations are also available from EPA.

	Title	Number	Time
(1)	Activated Sludge Process and Vacuum Filtration	S-160	8 min.
(2)	The Trickling Filter Plant	S-159	8 min.
(3)	The Primary Treatment Plant	X-138	7 min.

Important Vocabulary

waste water
sewage
septic tank
aerobic bacteria
BOD
yeast
primary sewage treatment
secondary sewage treatment
tertiary sewage treatment
organic matter
inorganic compounds
algae

Activity 11 - The Septic Tank

Objective:

1) Describe the 3 types of impurities that affect water quality.

2) Explain how a septic tank removes impurities from waste water and what the impurities are.

Notes:

The material on the pages just preceding this unit should serve as a lead in to the discussion of septic tanks. The chart of the septic tank absorption field was taken from the USDA document noted in the module. The document provides some very good information about septic tanks, but in some places does get somewhat technical. Soil and Septic Tanks may be obtained for .30 each from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 20402.

The followup activity is designed to help students see that what one person does with sewage can greatly affect someone else. The knowledge they gained in Activity 5 should aid them here. Note that septic tanks can not function properly where the water table is too close to the surface or where soil conditions aren't right. (The soil is too compacted or too porous.) In the above situations the liquids can not drain properly from the leaching field. An overhead transparency or ditto master can be made from the sheet provided.

Activity 12 - BOD and Sewage Treatment Plants

Objective:

1) Explain what BOD is and why it is an important factor in water quality. (Introduced in Activity 11)

2) Explain how primary, secondary and tertiary sewage treatment plants remove impurities from sewage and what impurities each removes.

3) Explain why it is important to remove the inorganic materials produced by sewage treatment plants.

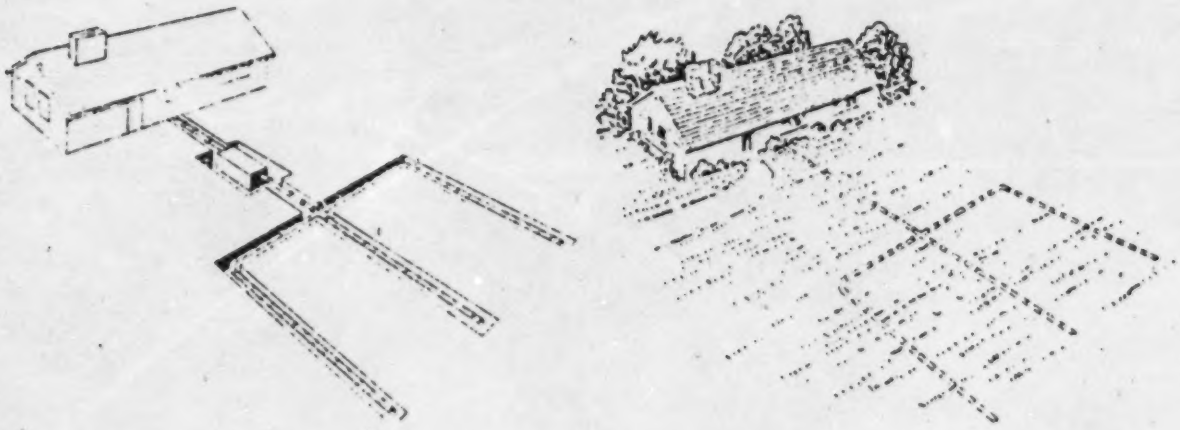
Notes:

This activity was taken from Environmental Science, Probing The Natural World/Level III of ISCS materials. The ISCS book provides more detailed information and additional activities in the same area. All of the materials for this lab are simple. Prepare the methylene blue solution by adding .1 gms of methylene blue crystals to 500 ml of water. If the solution is any more concentrated the reaction time will be increased. If the control tube does not react properly, rerun the experiment adding 5 drops of mild lactic acid to each test tube. Also be certain that your yeast are active.

A simple chemical test for the determination of dissolved oxygen is included here. This test was prepared by Lucy Pellitier, a student of Mr. Joe Clark at Clarke Central High School in Athens, Georgia.

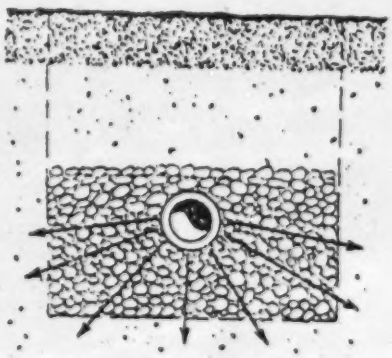
Activity 11 - The Septic Tank As A Primary Treatment

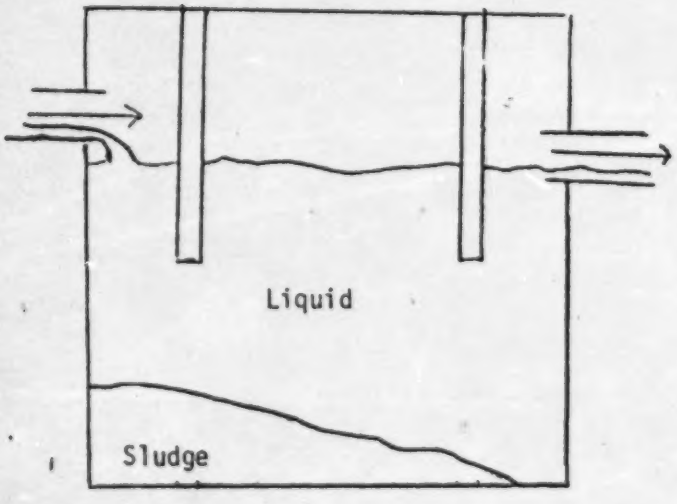
Below is a diagram of a septic tank and leaching field. Look it over carefully as your teacher explains it.



In a conventional septic-tank absorption field, draintile is laid in trenches (above, left). The tank and tile are covered with soil, and the area is planted to grass (above, right). The effluent from the tank is carried through the draintile to all points of the field where it is absorbed and filtered by the surrounding soil (right).

(Diagram above is from Soils and Septic Tanks, Bulletin 349, Soil Conservation Service, U.S. Department of Agriculture.)





Determination of Dissolved O_2

Reagents

1. Manganous Sulfate ($MnSO_4$)
2. Alkaline - Iodide (NaOH-KI)
3. .01 M Thiosulfate ($Na_2S_2O_3$)
4. Starch indicator
5. Concentrated H_2SO_4

Sampline Procedure

Collect your water in 250-300 ml volumes. Preferably use ground glass stoppers (I.E. - acid reagent bottles).

Tip bottle gently. Any bubbling or turbulence changes O_2 concentration. Your experiment will be more accurate if you siphon -- keeping the end of the siphoning tube below the H_2O level in bottle. Allow a volume of H_2O equal to 1/2 the volume of the bottle to over flow. Stopper.

Use surface samples -- A complicated suction set-up is required for accurate depth samples.

Analysis

1. O_2 content must be immediately fixed. Immediately after taking sample in the field - Add
   a) 1.0 ml manganous sulfate (by pipet) - A precipitate will form.
   b) Immediately follow with 1.0 ml alkaline - iodide soln (separate pipet).
   c) Stopper. Sample is now stable. It can be set aside for as long as your heart desires.

2. Add 1 ml concentrated H_2SO_4. Shake, ppt. will dissolve. If it doesn't, add more H_2SO_4, shake.

3. Solution is now red-brown. It must be titrated within the hour.

4. By pipet, transfer 50.0 ml of sample to an Erlenmeyer flask.

(Determination of Dissolved O_2 Continued)

5. From buret, add thiosulfate slowly swirling the sample as you add it. Add till solution is pale yellow. Record amount used. Record to hundreths (.00) place.

6. Add 5 ml starch indicator. Solution turns blue.

7. Add thiosulfate again, slowly, while swirling, till blue color disappears. Record amount used. Record to the hundreths (.00) place, if possible.

8. Record total amount thiosulfate used. (Steps 5 & 7)

9. Repeat procedure steps 3 through 8 two times if time permits.

Calculation

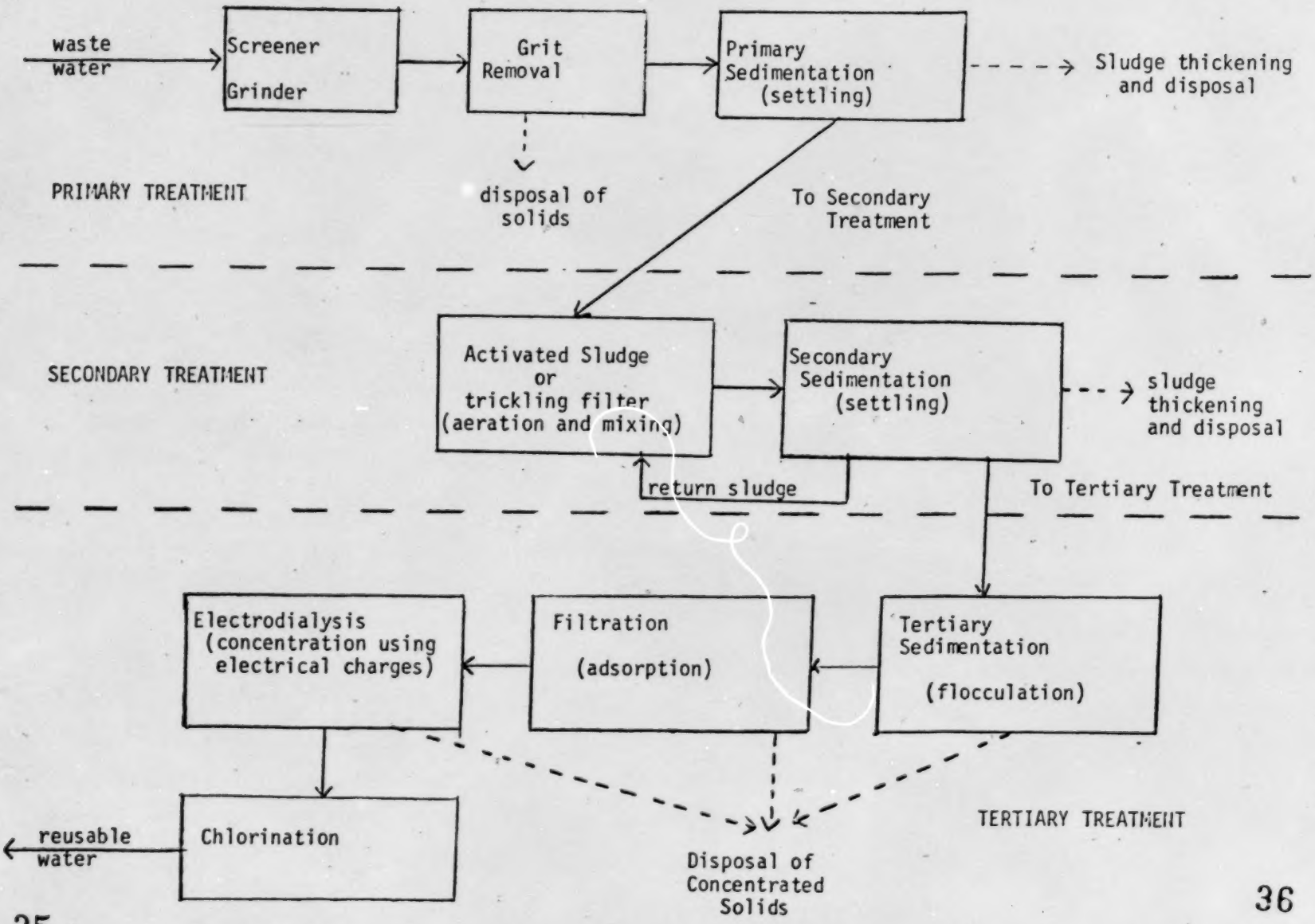
1. Multiply 1.12 x ml thiosulfate used. This gives the number of ml of O_2/l. (Not %) Percent is per hundred, this is per thousand.

2. Average your three answers and pray you're right.

Record Sheet For BOD Activity

	Test Tube 1	Test Tube 2	Test Tube 3	Test Tube 4
ml of milk	0	.5	3	6
ml of water	6	5.5	3	0
concentration of milk	0%	8.3%	50%	100%
time of mixing				
time of change				
total time for change				

A TYPICAL SEWAGE TREATMENT PLANT



Activity 13 - Field Trip to Sewage Treatment Plant

Objectives:

1) Explain why people should be concerned about getting diseases from water that contains sewage.

2) Explain how the school sewage treatment plant removes impurities from the water.

Notes:

This field trip provides the students with an opportunity to see an example of a relatively small treatment facility that combines primary and secondary treatment methods. Point out all the different type wastes that enter the plant: kitchen grease and detergent, bathroom sewage, art room wastes, and chemistry and biology laboratory wastes. Several schools have treatment plants which could be studied for an understanding of treatment processes.

The followup discussion on bacteria in sewage point out one of the most important problems of sewage disposal. The discussion questions should help to point out some of the serious consequences that must be considered in sewage disposal. Point out to the students the ideas that the supply of fresh water is limited, and that what one person does with water can affect many other people. Each handler of waste water has a responsibility to dispose of the wastes properly. Note that costs must be considered in the decisions to build sewage treatment plants. Very few tertiary treatment plants are built because of the higher construction and maintenance costs.

Part IV - The Water Game

This game is provided as a review activity to reinforce concepts and ideas learned during the previous activities. One might consider giving an award to the winner of the game. Because of the nature of the game all the questions have short, non-discussion answers. One might wish to modify the questions or playing procedure to fit class situations.

Game cards and information sheets can be copied from the following pages. A game board and spinner is not provided with the module, but can be easily made by one of your students. Instructions are in the text.

Overall, on completion of the module the students should be able to:

1. Analyze sewage disposal situations and determine which treatment system would be most appropriate.

2. Predict the effects of dumping waste water into a given river. Who would be affected and how.

3. Evaluate a given water supply system and make recommendations for improving and protecting the system.

The Water Game - Correct Answers by Number

1. The addition of coagulants to a liquid to cause the formation of floc and the settling of suspended materials is

   flocculation

2. Chemicals which are used to treat turbid liquids to cause suspended materials to settle out quicker are

   coagulants

3. Name the 3 categories of impurities found in water.

   1. dissolved chemical compounds
   2. suspended solid particles
   3. organic materials

4. The flocculation process is used in treating water and sewage because it removes much of the

   suspended materials

5. The coagulant that was used in the flocculation exercises was

   aluminum sulfate (or alum)

6. The operator of a sewage or water treatment plant should be concerned with the pH of the incoming fluid because the pH of the fluid affects the _____ process.

   flocculation

7. In Gwinnett County most of the waste water treatment is carried out in

   septic tanks

8. The part of the septic tank disposal system in which anaerobic bacteria decompose organic wastes is the

   septic tank itself

9. The part of a septic tank disposal system in which aerobic bacteria decompose organic waste is

   in the liquid in the leach lines

10. The amount of oxygen that is used up in the process of decomposing organic wastes is known as the

    biochemical oxygen demand

11. The letters BOD represent the words

Biochemical Oxygen Demand

12. What chemical was used as an indicator of the presence of oxygen in a solution?

methylene blue

13. Sewage treatment plants are classified by what they remove from the sewage. Primary treatment plants remove

most of the solids and some BOD

14. Choose only the correct answer. Water that contains waste products of human activity and which is a type of waste water is

sewage

15. Water that has been used by man or has come into contact with man is called

waste water

16. Sewage treatment plants are classified by what they remove from the sewage. Secondary treatment plants remove

the substances a primary plant does plus the remaining organic material

17. Sewage treatment plants are classified by what they remove from the sewage. Tertiary treatment plants remove

the substances that primary and secondary plants remove, plus chemicals and dissolved minerals.

18. A primary sewage treatment plant carries out its treatment process by

the physical removal of solid materials

19. In addition to the activities of a primary sewage treatment plant, the secondary treatment plant carries out its treatment process by:

aerobic decomposition of organic matter

20. In addition to the activities of primary and secondary sewage treatment plants, the tertiary plant carries out its treatment process by:

coagulation, filtration, and electro-dialysis of dissolved wastes

21. The chemical that is added to the discharge from any sewage treatment plant to kill as many of the remaining bacteria as possible is

chlorine

22. **The water from which of the sewage treatment plants should be safe to drink after leaving the facility?**

tertiary sewage treatment plant

23. **Why is it necessary to churn the mixture of an activated-sludge secondary sewage treatment plant?**

To provide a good supply of oxygen and fresh organic matter to the aerobic bacteria

24. **Name 2 reasons why tasting is not a good test of water quality.**

1. Water might contain harmful impurities
2. We can't taste some impurities

25. **Name 2 activities of man that can affect the quality of water in the water table.**

(Any two of these:)
1. leaking sewer lines
2. seepage from landfills and dumped garbage
3. run-off from agricultural activities or waste disposal seeping into the ground
4. septic tanks

26. **Name 2 activities of man that can affect the level or amount of water in the water table.**

(Any two of these:)
1. drawing water from springs or other surface sources
2. paving
3. bulldozing
4. sinking wells
5. changing the surface contour of the land

27. **What percentage of the earth's water is contained in the oceans?**

97%

28. **Of the fresh water on earth what percentage is available to man presently?**

22%

29. **What are the two main sources of fresh water presently available to man?**

1. underground water
2. surface water of rivers and lakes

30. **The physical change in which water molecules leave a body of water and enter the atmosphere as a vapor is the process of**

evaporation

31. The evaporation of water molecules released by green plants in the "breathing" process of respiration is

evapotranspiration

32. The small particles of solid material on which water molecules form to produce rain drops are called

condensation nuclei

33. The process in which water is sprayed into the air to kill bacteria which cannot survive in the presence of oxygen is

aeration

34. A topographic map shows or represents

surface features of an area

35. The cyclic processes of water involving evaporation and precipitation with the movement of water and water vapor on the earth is called the

hydrologic cycle

36. The area of the saturation of rocks and soil with underground water is the

water table

37. Water that is located under the surface of the earth and is moving from higher to lower elevation as a part of the hydrologic cycle is

ground water

38. Which of the following correctly describes the fate of water that evaporates from the oceans?

90% falls directly back into the ocean as precipitation and 10% falls onto land

39. How does the form or shape of the water table compare with that of the land surface?

Similar to the shape of the surface

40. How do paved areas such as parking lots and roads affect the movement of surface water?

Increases surface runoff

41. Which statement best describes the effect of chlorine on bacterial growth in water?

chlorine inhibits bacterial growth

42. How much of the world's available supply of fresh water is found in North America?

1/4

43. What is the source of most of Gwinnett County's water?

the Chattahoochee River

1. The addition of coagulants to a liquid to cause the formation of floc and the settling of suspended materials is _____.

2. Chemicals which are used to treat turbid liquids to cause suspended materials to settle out quicker are

3. Name the 3 categories of impurities found in water.

4. The flocculation process is used in treating water and sewage because it removes most of the _____

5. The coagulant that was used in the flocculation exercise was _____

6. The operator of a sewage or water treatment plant should be concerned with the pH of the incoming fluid because the pH of the fluid affects the _____ process.

7. In Gwinnett County most of the waste water treatment is carried out in _____.

10. The amount of oxygen that is used up in the process of decomposing organic wastes is known as the _____

8. The part of the septic tank disposal system in which anaerobic bacteria decompose organic waste is the _____.

11. The letters BOD represent the words _____.

9. The part of a septic tank disposal system in which aerobic bacteria decompose organic waste is _____.

12. What chemical was used as an indicator of the presence of oxygen in a solution?

13. Sewage treatment plants are classified by what they remove from the sewage. Primary treatment plants remove _____.

16. Sewage treatment plants are classified by what they remove from the sewage. Secondary treatment plants remove _____

14. Choose the correct answer. Water that contains waste products of human activity and which is a type of waste water is:

a) precipitation
b) fresh water
c) sewage
d) treated water

17. Sewage treatment plants are classified by what they remove from the sewage. Tertiary treatment plants remove _____

Choose the correct answer. Water that has been used by man or has come into contact with man is called

a) fresh water
b) waste water
c) precipitation
d) treated water

18. Choose the correct answer. A primary sewage treatment plant carries out its treatment process by

a) the physical removal of solid materials
b) aerobic decomposition of organic matter
c) coagulation, filtration and electro-dialysis of chemical wastes
d) anaerobic decomposition or organic matter

19. Choose the correct answer. In addition to the activities of a primary sewage treatment plant, the secondary treatment plant carries out its treatment process by:

a) the physical removal of solid materials
b) coagulation, filtration and electro-dialysis of chemical wastes
c) anaerobic decomposition of organic matter
d) aerobic decomposition of organic matter

20. Choose the correct answer. In addition to the activities of primary and secondary sewage treatment plants, the tertiary plant carries out its treatment process by:

a) the physical removal of solid materials
b) coagulation, filtration, and electro-dialysis of dissolved wastes
c) aerobic decomposition of organic matter
d) anaerobic decomposition of organic matter

21. The chemical that is added to the discharge from any sewage treatment plant to kill as many of the remaining bacteria as possible is _____.

22. The water from which of the sewage treatment plants should be safe to drink after leaving the facility?

23. Choose the correct answer. Why is it necessary to churn the mixture of an activated-sludge secondary sewage treatment plant?

a) To provide a good supply of oxygen and fresh organic matter to the anaerobic bacteria
b) To remove settleable material
c) To provide a good supply of oxygen and fresh organic matter to the aerobic bacteria
d) To deoxygenate the mixture thus killing the aerobic bacteria

24. Name 2 reasons why tasting is not a good test of water quality.

25. Name 2 activities of man that can affect the quality of water in the water table.

26. Name 2 activities of man that can affect the level or amount of water in the water table.

27. What percentage of the earth's water is contained in the oceans?

28. Of the fresh water on earth what percentage is avilable to man presently?

29. What are the two main sources of fresh water presently available to man?

30. The physical change in which water molecules leave a body of water and enter the atmosphere as a vapor is the process of _____.

31. The evaporation of water molecules released by green plants in the "breathing" process of respiration is _____.

32. The small particles of solid material on which water molecules form to produce rain drops are called _____.

33. The process in which water is sprayed into the air to kill bacteria which cannot survive in the presence of oxygen is _____.

34. Choose the correct answer.
A topographic map shows or represents

a) population statistics per area
b) zoning areas
c) projected growth of an area
d) surface features of an area

35. The cyclic processes of water involving evaporation and precipitation with the movement of water and water vapor on the earth is called the _____.

36. The area of the saturation of rocks and soil with underground water is the _____.

37. Water that is located under the surface of the earth and is moving from higher to lower elevation as a part of the hydrologic cycle is _____.

38. Choose the correct answer: Which of the following correctly describes the fate of water that evaporates from the oceans?

a) 10% falls directly back into the oceans as precipitation and 90% falls onto land.
b) Half of it falls directly back into the ocean as precipitation and half of it falls onto land.
c) 90% falls directly back into the ocean as precipitation and 10% falls onto land.
d) All the water falls directly back into the ocean as precipitation.

39. Choose the correct answer. How does the form or shape of the water table compare with that of the land surface?

a) High where land surface is low and low where land is high.
b) Similar to the shape of the surface.
c) In underground ponds in valleys.
d) In underground streams that follow the shape of the land surface.

40. Choose the correct answer. How do paved areas such as parking lots and roads affect the movement of surface water?

a) Increases surface runoff
b) Decreases surface runoff
c) Allows more water to soak in
d) Provides good channels for the movement of water

41. Choose the correct answer. Which statement best describes the effect of chlorine on bacterial growth in water?

a) chlorine stimulates bacterial growth
b) chlorine has no effect on bacterial growth
c) chlorine inhibits bacterial growth
d) chlorine acts as a fertilizer

42. Choose the correct answer. How much of the world's available supply of fresh water is found in North America?

a) 1/10
b) 1/4
c) 1/3
d) 1/2

43. What is the source of most of Gwinnett County's water?